ENVIRONMENTAL ASSESSMENT

FOR

PROPOSED BOOSTER APPLICATIONS FACILITY (BAF)

AT

BROOKHAVEN NATIONAL LABORATORY,

UPTON, NEW YORK

JANUARY 1998

DOE/EA-1232

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1.0 INTRODUCTION

Simulation of space radiation requires the capability to produce protons and electrons at relatively low energies and heavy and light ions at energies up in the GeV per nucleon range. Availability of these particles is essential to calibrate spacecraft radiation detectors, establish a comprehensive understanding of radiobiology, assess radiation shielding needs for space missions, define the full impact of space radiation on sensitive electronic components, and other studies involving simulated space radiation environments. These low-energy protons, heavy ions, and electrons can be delivered as beams in ground-based accelerators. No facility in the United States currently has the capabilities to meet national space radiation research needs for heavy ions.

In July 1992, a Memorandum of Understanding regarding energy-related civil space activities between NASA and DOE was established. In April 1994, a complementary agreement between NASA and Brookhaven National Laboratory (BNL) was signed. In July 1997, a Memorandum of Understanding regarding the implementing arrangements between DOE, NASA, and BNL was established. This 1997 agreement defines responsibilities for construction and cost for a high-energy, heavy ion irradiation facility at BNL.

2.0 PURPOSE AND NEED FOR ACTION

The DOD, DOE, and NASA have identified a national need for a facility that could conduct space radiation research. No facility in the United States currently exists which is capable of meeting the space radiation research needs involving the use of heavy ions. This environmental assessment describes the alternatives considered and associated environmental impacts with the location, construction, operation, and decommissioning of such a facility at BNL.

3.0 DESCRIPTION OF ALTERNATIVES, INCLUDING THE PROPOSED ACTION

3.1 Proposed Action

The proposed action is to construct research facilities and associated structures at Brookhaven National Laboratory that would utilize protons, light ions, and heavy ions at energies up to the GeV per nucleon range. Particles at these energies are present in the AGS Booster prior to injection into the AGS where further acceleration of particles takes place.

3.2 No-Action Alternative

The No-Action alternative would best be described as a "taking no action" alternative. No new construction or modifications of current facilities at BNL would be pursued to facilitate the space radiation research program. Only one facility world-wide that generates the appropriate beams for space radiation research, the Schwerionen Synchrotron facility at Geselschaft fur Schwerionenforschung, Darmstadt, Germany.[1] This facility offers less than an ideal situation to the U.S. space radiation research program because it is heavily subscribed for other nuclear physics research, it is not likely to offer sufficient time, and future use cannot be prioritized by the United States, therefore making facility availability unreliable.

3.3 Preferred Alternative

The Preferred Alternative would result in constructing and operating a space radiation research facility north of BNL's AGS Booster. This facility would be known as the Booster Applications Facility (BAF). Construction of the BAF would require the following:

- Upgrade the MP6 Tandem Van de Graaff accelerator and connect it into the existing Tandem to Booster (TTB) line;

- Install a beamline with diversion magnets off the northwest quadrant of the Booster;

- Construct beam penetrations that could direct beam to initially one and potentially up to three experimental facilities within the new BAF;

- Construct a new 250 square meter building and trailer area which would house a target area, laboratory facilities, shielding, power supplies, and a beam stop; and

- Construct a new paved roadway on the west side of the proposed facility to maintain the continuity of West Fifth Avenue.

Potential future upgrade activities would be characterized by the installation or replacement of modernized or improved equipment including such items as power supplies and computer systems, and the construction of possibly two more target areas with trailer-size laboratory facilities. The future target areas would be similar in size to the initial target area and would be contiguously located. Penetrations in the beamline would be built to accommodate this potential future addition.

The connection of the MP6 Tandem Van de Graaff to the TTB would require the installation of approximately 70 meters of beam line in the existing enclosure and magnets to properly direct the beam. Beam line construction would consist of the manufacture and installation of vacuum systems, vacuum chambers, magnets, and power supplies.

Once the beam is diverted out of the Booster, it would travel through a 27 meter beam line where it would be diverted 20^{o}. The beam would be redirected down a pathway 80 meters long where it would enter a 121.5 square meter experimental facility at the BAF. A new 250 square meter building connected to the experimental areas would provide the necessary support facilities for the experimental area, room size support laboratories, temporary biological specimen preparation areas, radiobiological laboratories, offices, a beam control room, a mechanical service equipment area and rooms for storage of radioactive materials, and miscellaneous items. A separate 108 square meter power supply building would also be constructed.[2] These buildings would be constructed at grade adjacent to the Booster in an area where young locust and cherry trees are growing. Once completed and operational the BAF could receive enough low-energy protons and heavy ions from the Booster to support 1,500 hours per year of space radiation research. The proposed experimental facilities for the Proposed Action Alternative are shown in Figure 3-1.

3.4 South Alternative

An alternative to the Proposed Action, designated the South Alternative, would involve construction and operation of a space radiation research facility south of the BNL Booster. Construction of this alternative would include all of the components of the Preferred Alternative as displayed in Figure 3-2.. Additional actions needed for this alternative would be:

- Extension of the beam line across the LINAC injection tunnel to the AGS and the TTB;

- Construction of a retaining wall to protect the former Radiation Effects Facility (REF);

- Installation of a beam line with diversion magnets off the southeast quadrant of the Booster; and

- Relocation of Michelson Avenue to the west side of the former Neutral Beam Test Facility (NBTF).

The exit point in the Booster for the beam would be in the southeast quadrant for this alternative. Once the beam is diverted out of the Booster, it would travel through 68.6 meters of beam line, crossing the Linac injection tunnel to the AGS and the TTB. At that point it would enter a pentagonal switchyard where the southwest traveling beam would be diverted in a more southerly direction. From that point, the beam would travel an additional 41.8 meters adjacent to the retaining wall constructed to protect the former Radiation Effects Facility. The beam would then enter the beamline for diversion into an experimental facility. The experimental facilities would be connected via a 38.7 meter beam line. Beyond this point the support facilities would be constructed the same as for the Preferred Alternative. The beam line and experimental facilities associated with this alternative for the BAF would be constructed upon previously disturbed sparsely vegetated sandy soils. Elevation of the new facilities would be 6.1 to 9.1 meters below the existing grade. Like the Preferred Alternative, only one of the proposed beam lines and associated experimental facilities would be initially constructed.

Figure 3-1: Booster Applications Facility, Preferred Alternative

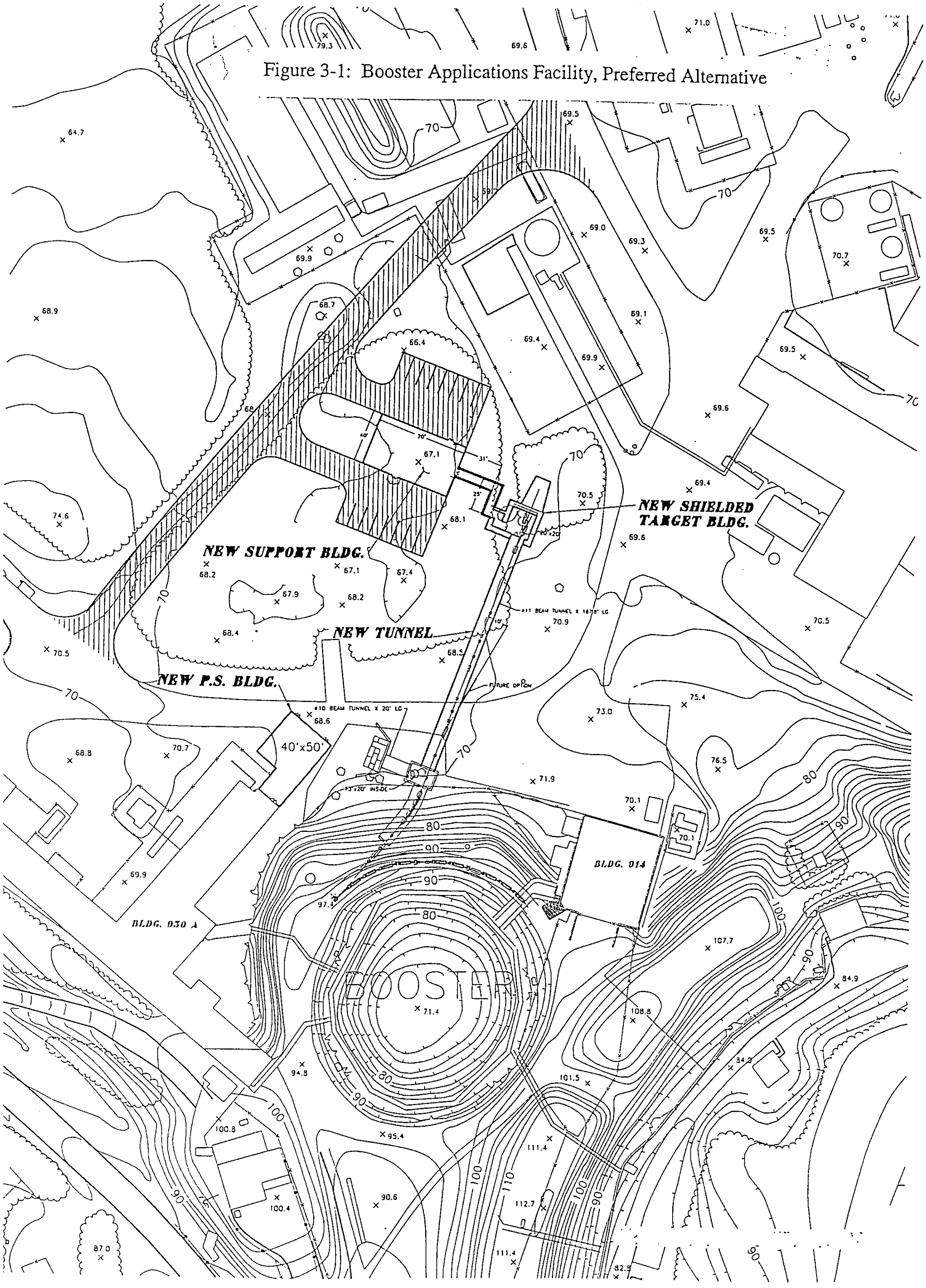
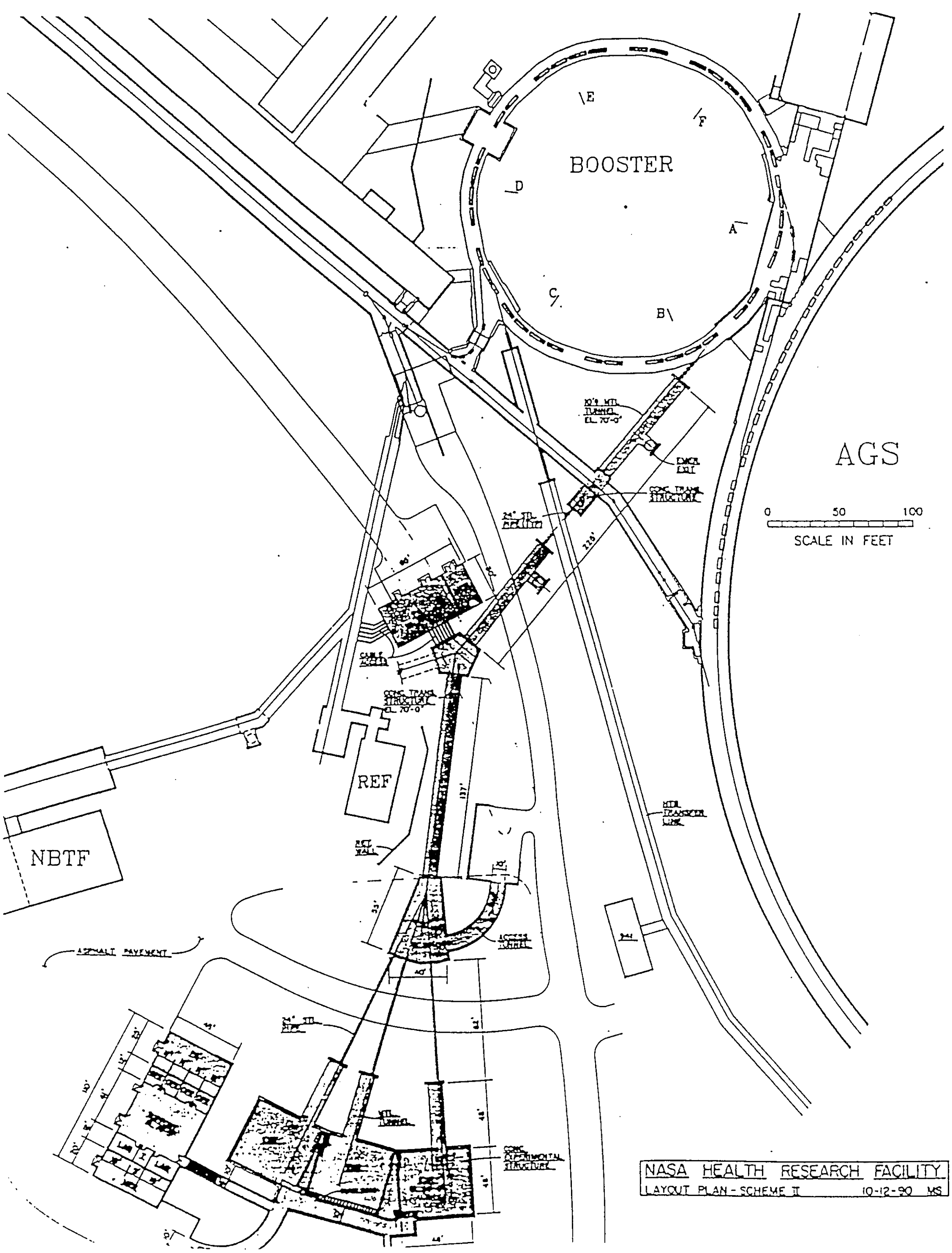


Figure 3-2: Booster Applications Facility, South Alternative



4.0 SITE FACILITY DESCRIPTION

4.1 General Site Description, Brookhaven National Laboratory

Brookhaven National Laboratory is a multi disciplinary scientific research center located close to the geographical center of Suffolk County, New York, about 97 kilometers east of New York City. A general overview of BNL is provided in Figure 4-1. About 1.33 million persons reside in Suffolk County and about 0.42 million persons reside in Brookhaven Township, within which the Laboratory is situated.[5] Approximately 8,000 persons reside within one half kilometer of the Laboratory boundary. Although much of the land area within a 16 kilometer radius remains either forested or cultivated with no major construction having occurred since 1978, there has been an increase in residential housing development in the rural areas surrounding BNL. However, detailed plans for two shopping centers, a corporate park, and several thousand single and multiple family dwellings are proposed within a 15 kilometer area of BNL, predominantly on the north, south, and west boundaries.

A wide variety of scientific programs are conducted at BNL. These programs contribute to the cumulative environmental impact realized by current BNL operations. The major scientific facilities used to conduct research and development at BNL are described below:

1) The High Flux Beam Reactor is fueled with enriched uranium, moderated and cooled by heavy water, and has operated at a power levels of 30 to 60 Megawatts (MW) thermal since 1965. This facility was temporarily shut down in January 1997 following a discovery that the spent nuclear fuel pool was leaking and caused on-site contamination of the Upper Glacial Aquifer with tritiated water. An Environmental Impact Statement is being prepared to analyze the future of this facility.

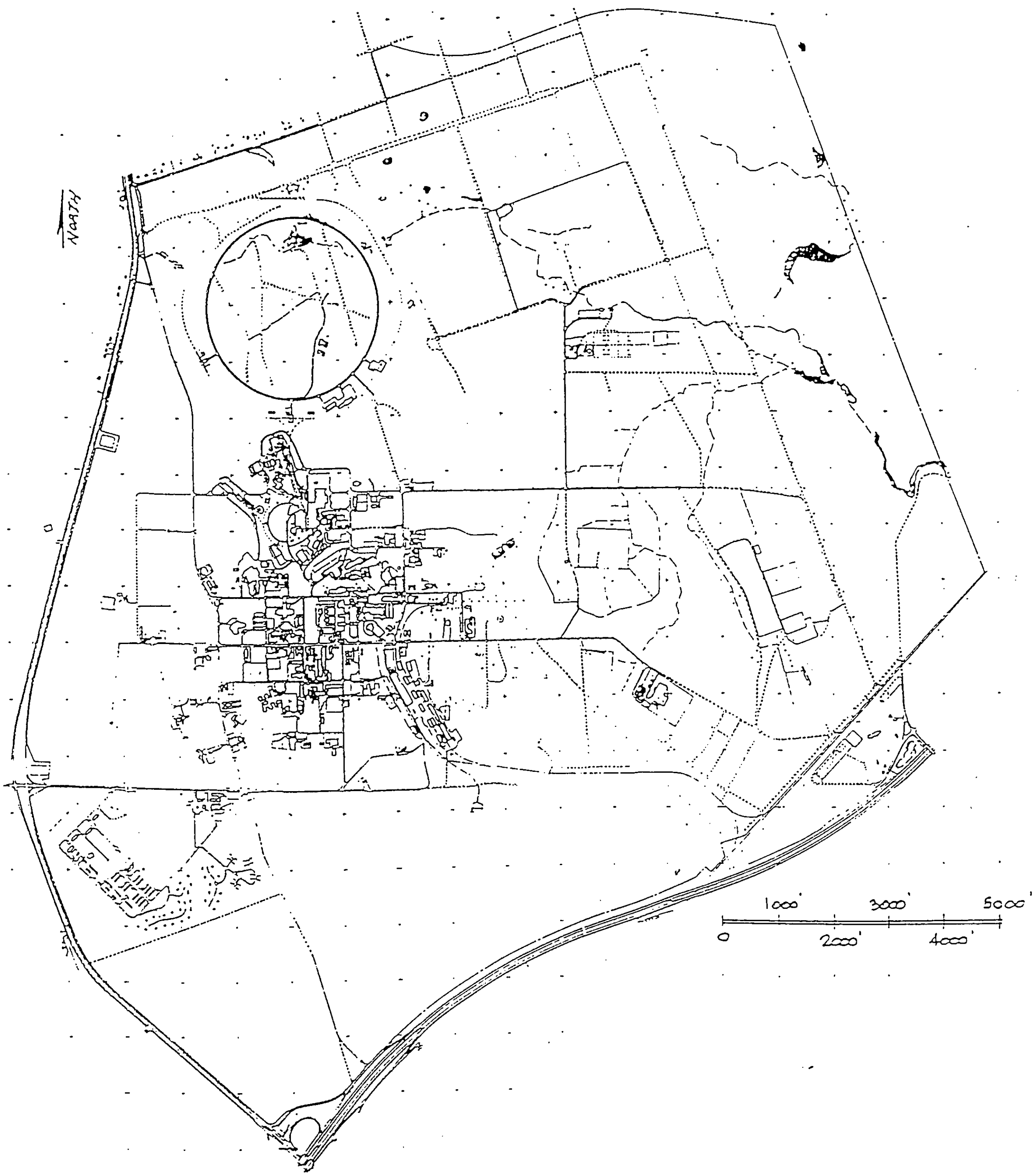
2) The Medical Research Reactor (MRR), an integral part of the Medical Research Center (MRC), is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 MW thermal. The MRR is primarily used for boron neutron capture therapy research for treatment of glioblastoma multiforme brain tumors.

3) The AGS is used for high energy and nuclear physics research and accelerates protons ranging in energy up to 30 GeV and heavy ions (ranging in mass close to iron up to gold) to 15 GeV/amu.

4) The 200 MeV Linear Accelerator (LINAC) serves as a proton injector for the AGS and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven LINAC Isotope Production Facility.

5) The Tandem Van de Graaffs, Cyclotrons, and other accelerators ranging to 10 MeV are used in medium energy physics investigations, technological applications, special nuclide production, and radiochemistry investigations. The Tandem Van de Graaff identified as

Figure 4-1: Overview of Brookhaven National Laboratory Site



MP7 is also used to inject heavy ions via a beam line (TTB) into the AGS for use in physics experiments.

6) The National Synchrotron Light Source utilizes a LINAC and booster synchrotron as an injection system for two electron storage rings which operate at energies of 750 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). The synchrotron radiation from the stored electrons is used for VUV spectroscopy and x-ray diffraction studies.

7) The AGS Booster is a circular accelerator with a circumference of 200 meters that receives either a proton beam from the LINAC or heavy ions from the Tandem Van de Graaff. The Booster accelerates protons and heavy ions prior to injection into the AGS ring.

8) The Radiation Therapy Facility, operated jointly by the Medical Department and the State University of New York at Stony Brook, is a high energy dual X-ray mode linear accelerator used for the radiation therapy of cancer patients.

9) The Relativistic Heavy Ion Collider (RHIC) now under construction and expected to be operational in 1999, would produce beam-beam collision center of mass energies of up to 40 TeV to facilitate investigations in nuclear physics, particle physics, and astrophysics.[4]

10) The Accelerator Test Facility consists of a high brightness 10 MeV linear accelerator used for accelerator physics research.

11) The Pulse Radiolysis Facility uses a 10 MeV photocathode electron gun for studies on the kinetics and mechanisms of rapid chemical reactions induced by ionizing radiation.

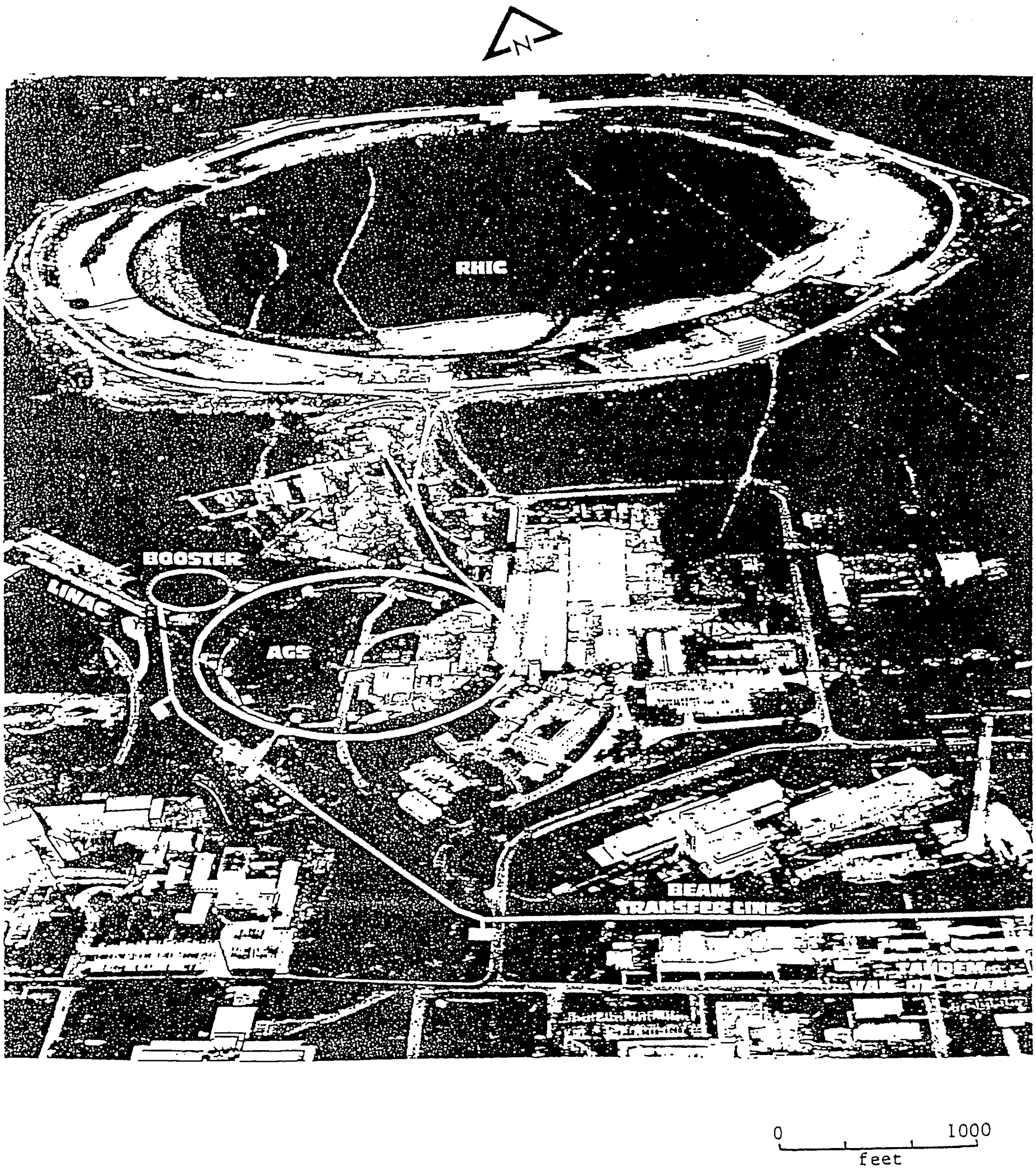
12) The Waste Management Facility which provides BNL with the capability to meet its hazardous, mixed and radioactive waste management storage, packaging and transportation requirements into the next century.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried out at other Laboratory facilities including those of the Biology Department, Chemistry Department, Department of Applied Science (DAS), Medical Department, and Physics Department. Special purpose radionuclides are developed and processed for general use under the joint auspices of the DAS and Medical Department.

4.2 Site Description and History, Accelerator Facilities

The Booster is an accelerator which began operations with protons and heavy ions in April 1992. Particles injected into the Booster presently originate from the MP7 Tandem Van de Graaff or the 200 MeV LINAC. The Tandem Van de Graaff accelerators (MP6 and MP7), operational since 1970, supply heavy ions which are accelerated, transported through the TTB line completed in 1991, and injected into the Booster. A 200 MeV LINAC provides proton pulses to the Booster and has been providing the AGS protons since 1970. The maximum kinetic energy available from Booster beams is 4.4 GeV for protons and 0.35 to 1.5 GeV per nucleon for heavy ions. Lighter heavy ion energies of mass close to iron range up to 1.5 GeV per nucleon and the maximum energy of the heaviest ions, gold ions, is 0.35 GeV per nucleon.[5] The Booster acts as a pre-accelerator to the AGS which in turn can accelerate protons to 30 GeV/c and 11 GeV/amu for gold ions. Besides experimentation beam lines using accelerated particles from the AGS, the construction of a relativistic heavy ion collider (RHIC) is now under way and is expected to accelerate AGS injected gold ions up to 100 GeV/amu. The AGS would compete with the BAF to obtain Booster accelerated particles for research once obligations to the RHIC are met. The RHIC requires approximately one hour of AGS and Booster operation time for each twelve hour shift. Figure 4-2 displays the major accelerator and injection facilities present and/or under construction at BNL.

Figure 4-2: Major Brookhaven National Laboratory Accelerators



5.0 AFFECTED ENVIRONMENT

This section contains a description of the environmental conditions present at BNL which could be potentially impacted if one of the proposed alternatives is implemented. Section 5-3 provides general environmental information for the surrounding BNL site which is important for cumulative impact analyses. Specific features of importance for the Preferred and South Alternatives are presented in Sections 5-1 and 5-2, respectively. More detailed information concerning the existing environment may be found in BNL's 1995 Site Environmental Report which is listed in the References section.[5]

5.1 Site Description, General Site

5.1.1 Land Use and Demography

The Nassau-Suffolk Bicounty Master Plan guides future development on Long Island. This guidance is complemented on the local level by a Brookhaven Town Master Plan. In both of these documents the operation of the Laboratory, and anticipated future projects are considered in terms of the projected land use, and population distribution for Long Island.

Suffolk County population was estimated to be 1.33 million in 1995.[3] Approximately 0.42 million of these people reside in Brookhaven Town and 8,000 within 0.5 kilometers of the Laboratory boundaries. Although there has been an increase in residential housing development in the rural area surrounding BNL, there have been no major construction projects in the vicinity since 1978. However, detailed plans for two shopping centers, a corporate park, and several thousand single and multiple family dwellings are proposed within a 15 kilometer area of BNL, predominantly on the north, south, and west boundaries.

The Laboratory site encompasses 21.3 square kilometers with development clustered within 6.7 square kilometers toward the center of the site. Outlying facilities within the Laboratory include the Sewage Treatment Plant, research agricultural fields, housing, and fire breaks covering an additional 2.2 square kilometers. The balance of the site is largely wooded and undeveloped except for cut access unpaved roadways to permit monitor well installation and sampling.

5.1.2 Geology and Seismology

Long Island was formed by two east-west trending glacial moraines, deposited during two separate Pleistocene glaciation events. Just west of the Laboratory the two moraines are connected by a narrow north/south ridge for which the hamlet of Ridge is named. East of this ridge, and enclosed by it and the two moraines, is the Manorville Basin. The Laboratory grounds are on the Basin's relatively high west margin. The general surficial geology of the region consists of deposited glacial sands and gravels of Pleistocene age. These deposits, which range in depth from 20 to 38 meters, lie on the Magothy formation, a unit of unconsolidated sands and clays of Late Cretaceous age. Surface deposits vary in texture from place to place.

The probable occurrence of an earthquake sufficiently intense to damage buildings and reactor structures in the BNL area has been thoroughly investigated as part of the planning for construction of the Brookhaven Graphite Research Reactor, High Flux Beam Reactor, and Relativistic Heavy Ion Collider. It is the consensus of seismologists that no significant earthquakes are to be expected in the foreseeable future. No earthquake has yet been recorded in the BNL area with an intensity in excess of modified Mercalli III, equivalent to 1 to 8 cm/sec^2 acceleration.[4] However, since Long Island lies in a Zone 1 seismic probability area, it has been assumed that an earthquake of Intensity VII, 5.6 on the Ritcher scale (e.g., negligible damage of good design and construction), could occur.[6] Liquefaction potential of soils at BNL for such an event is negligible given existing soil density and saturation parameters. Thus, structural stability should remain through an event of this magnitude. No active earthquake-producing faults are known in the Long Island area.[7]

5.1.3 Surface Water Hydrology

The BNL site terrain is gently rolling, with elevations varying between 13.3 and 36.6 meters above sea level. The land lies within the headwaters region of the Peconic River watershed. Wetland areas in the north and eastern section of the site were formerly a principle tributary of the Peconic River. The Peconic River both recharges to, and receives water from, the groundwater aquifer depending on the hydrological potential. Thus the river is classified as having intermittent flow on site. In 1995, the Peconic River on-site was recharging to groundwater leaving no measurable continuous flow at the site boundary point where the river exits. Liquid effluents from the BNL Sewage Treatment Plant (STP) constitute the only continual source of surface water in the tributary's river bed. In 1995, these liquid effluents also recharged to groundwater prior to leaving the site boundary. Combined industrial and sanitary wastewater discharged from the STP receives tertiary treatment and conforms to the criteria in the STP's approved SPDES permit issued by the New York State Department of Environmental Conservation (NYSDEC).[3]

5.1.4 Groundwater Hydrology

The aquifer is in dynamic equilibrium and receives precipitation of about 123 centimeters per year, or recharge of about 1.5 million liters per day per square kilometer. The water table height varies from the surface to a depth of 23 meters below land surface. The water table gradient averages about 0.11 meters change over 125 meters, with its elevation fluctuating 0.62 - 1.25 meters over the last few years. The uppermost Pleistocene deposits, referred to as the Upper Glacial Aquifer, range from 31 - 61 meters thick and are generally composed of highly permeable glacial sands and gravels. Water readily penetrates these sediments and allows little direct runoff into surface waters. The site occupied by BNL is classified by the Long Island Regional Planning Board and Suffolk County as a deep-flow recharge zone for Long Island meaning recharge in these areas also serve to replenish the lower aquifer systems identified as the Magothy and Lloyd Aquifers.

Ground water movement is primarily in a southerly direction with a horizontal velocity range of 22 to 30 centimeters per day.[8] Ground water flow in the northeast and northwest portions of the site is towards the Peconic River which moves in a southeasterly direction. Otherwise the directional movement of groundwater is to the south/southeast although it is more due south on the western edge of the site. Some groundwater mounding occurs near the STP and recharge basins. Localized directional changes in groundwater flow also occur as a result of BNL process and supply well pumpage. The Laboratory uses approximately 14 million liters of groundwater per day to meet potable water needs plus heating and cooling requirements. Approximately 70% of the total pumpage is returned to the aquifer through on-site recharge basins. About 15% is discharged into the Peconic River through the STP. Human consumption utilizes 4%, while evaporation and exfiltration from sanitary systems result in losses of 9% and 2%, respectively.

5.1.5 Meteorology

The BNL site weather is greatly influenced by the Atlantic Ocean, Long Island Sound, and the many associated coastal estuaries. Their presence moderates both summer and winter temperatures, strongly influences wind and humidity patterns, and greatly reduces the snowfall when compared to that measured at a nearby inland station. The site is well ventilated by winds from all directions with rapid, fairly consistent fluctuations in atmospheric stability. The prevailing ground level winds are from the southwest during the summer, from the northwest in the winter, and about equally from these directions during the spring and fall. The average temperature in 1995 was 10.6 degrees Celsius and the range was -6.9 to 29.10 degrees Celsius. The total precipitation for 1995 was 100.08 centimeters, which was roughly 22 centimeters below the latest 40 year annual average.[3]

5.1.6 Ecology

The Laboratory is located in a section of the Oak/Chestnut forest region of the Coastal Plain. Because of the general topography and porous soil, there is little surface runoff or open water. Upland soils tend to be drained excessively, while depressions form small pocket wetlands. Hence, a mosaic of wet and dry areas on the site are correlated with variations in topography and depth to the water table. In the absence of fire or other disturbance, the vegetation normally follows the moisture gradient closely. In actuality, vegetation onsite is in various stages of succession which reflects the history of disturbances to the area, the most important having been land clearing, fire, local flooding, and draining.

The Central Pine Barrens Joint Policy and Planning Commission has designated the north, east, and southern perimeters of the Laboratory as Pine Barrens Core Preservation Area as part of a Pine Barrens Comprehensive Land Use Plan. This plan was established to protect sensitive habitats associated with the pine barrens of Long Island and the principle recharge areas for the Long Island Aquifer system. The central portion of the Laboratory is designated as a compatible growth area. All alternatives under consideration lie within the northern portion of the designated compatible growth area.

Mammals common to the site include species common to mixed hardwood forests and open grassland habitats. At least 180 species of birds have been observed at BNL, a result of its location within the Atlantic Flyway and the scrub/shrub habitats which offer food and resting opportunities to migratory songbirds. Open fields bordered by hardwood forests found at the recreation complex provide excellent hunting areas for hawks. Pocket wetlands with seasonal standing water provide breeding areas for amphibians. Permanently flooded retention basins and other watercourses support aquatic reptiles.

Except for occasional transient individuals, no Federal or New York State listed or proposed threatened or endangered species exist within the project impact area [9,10]. The tiger salamander (Ambystoma tigrinum) is a New York State endangered species which has been found to breed and inhabit several wetlands on the Laboratory site but not within the immediate project impact area. Other New York State species of special concern observed at BNL include the spotted salamander (Ambystoma maculatum), spotted turtle (Clemmys guttata), eastern hognose snake (Heterodon platyrhinos), and eastern bluebird (Sialia sialis). Other protected species observed as transients to the Laboratory include the osprey (Pandion haliateus), peregrine falcon (Falco peregrinus), and common nighthawk (Chordeiles minor). One New York State species of special concern which has been confirmed as an inhabitant downstream of the project area is the banded sunfish (Enneacanthus obesus). This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act.

The wide variety of wildlife resources at BNL attest to Laboratory planning practices which have clustered development to minimize habitat fragmentation, particularly in environmentally sensitive areas such as the Peconic River corridor.

5.1.7 Baseline Radiological Characteristics

Brookhaven National Laboratory evaluates ambient levels of radioactivity through its environmental monitoring program. Measurements are made of direct exposures as well as activity in air, water, and soil. The following data was obtained from BNL's 1995 Environmental Monitoring Report.[3]

5.1.7.1 External Radiation Exposure

Thermoluminescent dosimeters are used to monitor the external exposure at onsite and offsite locations. The average annual onsite integrated dose for 1995 was 70 plus or minus 6 mrem, while the offsite integrated dose was 65 plus or minus 6 mrem. These levels are typical of those measured throughout the northeastern United States and within the normal background exposure range.

5.1.7.2 Atmospheric Radioactivity

Tritium, oxygen-15, and argon-41 were the predominant airborne radionuclides discharged and detected in environmental air samples. The maximum annual average tritium concentration at the site boundary in 1995 was 8.9 pCi/m^3. This concentration would result in a committed effective dose equivalent of 0.0007 mrem to the maximally exposed individual residing at the site boundary for the entire year. The effective dose equivalent to the maximally effected individual resulting from the inhalation and exposure of air effluents from BNL operations was 0.06 mrem. Most of this dose was attributed to Argon-41 emitted during operation of the Medical Research Reactor. This dose is far below the 10 mrem standard set by 40 Code of Federal Regulations (CFR) 61 for the air pathway.

5.1.7.3 Radioactivity in Precipitation

In 1995, precipitation was collected from two monitoring stations on a monthly basis and analyzed for radioactive content. These samples were routinely below the minimum detection limit for gross alpha activity measurements, below or near the minimum detection limit for gross beta activity, and near or below the minimum detection limit for tritium. Tritium measurements related to Laboratory emissions were not detectable above background levels for tritium in rainfall or snowfall. Gross beta activity was determined through gamma spectroscopy to be the result of terrestrial or cosmogenic radionuclides such as potassium-40, bismuth-211, and thallium-208.

5.1.7.4 Radioactivity/Other Contaminants in Water Supplies

Although the Peconic River is not utilized as a drinking water supply or irrigation source, the River recharges the aquifer which is the source of regional drinking water and supports a limited sports fishery. To evaluate the potential maximum dose to an individual from water ingestion, radiological analysis of private wells adjacent to BNL is performed routinely via a cooperative environmental surveillance program with the Suffolk County Department of Health Services. During 1995 the only radionuclide detected above background in any private well sampled was tritium. The maximum tritium concentration observed during the 1995 sampling program was 2,520 pCi/L. This concentration is far below the established Safe Drinking Water Act limits and represents an annual dose to the maximally effected individual of 0.1 mrem assuming consumption of two liter per day for 365 days. The dose limit specified by the Safe Drinking Water Act is 4 mrem/yr.

During December 1996 and following in 1997, a tritium plume was detected in ground water emanating from the spent fuel pool of the High Flux Beam Reactor. This plume was delineated and a pump and recirculate system was installed and is currently operating to contain this contamination on site and permit natural decay of the tritium to background levels while within Laboratory boundaries. No onsite operating potable wells have been impacted or are within the path of this plume. Other plumes containing solvents are currently under remediation as part of the Superfund process. Primary remediation efforts in place are also pump and recirculation practices including the use of air stripper and carbon filters to remove contaminants and recharge water meeting drinking water standards for the contaminants involved. As an added precaution, the Department of Energy has financially supported the hookup of communities south and southeast of the Laboratory to public water supplies. No Suffolk County Water Authority wellfields have been impacted by past Laboratory practices. Well fields south of the Laboratory are monitored routinely as are all well fields operated by the Water Authority as required by the Safe Drinking Water Act.

5.1.7.5 Radioactivity in Finfish

Fish are collected annually from ponds along the Peconic River downstream of BNL to determine the potential for ingestion of radioactivity. The highest radionuclide concentrations detected in 1995 were in Donahue's Pond, a water body currently under the limited access control of a private hunting and fishing club. Cesium-137 was detected in samples from Donahue's Pond at levels above those observed in fish taken from Lower Lake on the Carmans River in Yaphank, New York. Lower Lake is used as a control to water bodies on the Peconic River because it is considered outside of the influence of BNL emissions. The maximum net concentration (above control levels) of cesium-137 observed in fish collected from Donahue's Pond was 615 pCi/kg. For dose evaluation it was assumed an individual would eat seven kilograms of fish from Donahue's Pond during the course of a year resulting in a maximum dose at this consumption rate of 0.2 mrem. Quantification of strontium-90 was not available for 1995. In the past, doses related to strontium-90 via this pathway have averaged approximately 0.5 mrem per year. By comparison, the average individual dose caused by ingestion of naturally-occurring radionuclides in the United States is about 40 mrem per year.

5.1.7.6 Radioactivity in Soil or Vegetation

Offsite soil and vegetation sampling is conducted semiannually as a cooperative effort between BNL and the Suffolk County Department of Health Services. Radionuclides detected in vegetation and soil in the vicinity of BNL included beryllium-7, potassium-40, cesium-137, radium-226, and thorium-228. Observed concentrations represent the contributions of primordial and cosmogenic sources, and weapons test fallout. No nuclides attributable to Laboratory operations were detected in soil and vegetation samples collected.

5.1.7.7 Collective (Population) Dose Equivalent

The collective (population) dose equivalent (total population dose) beyond the site boundary, within a radius of 80 kilometers, attributed to Laboratory operations during 1995 was 3.36 person-rem. By comparison, the collective dose equivalent during 1995 due to external radiation from natural background to the population within an 80 kilometer radius of BNL amounts to about 291,000 person-rem to which about 97,000 person-rem should be added for internal radioactivity from natural sources.

The committed effective dose-equivalent to the maximum exposed individual resident at the site boundary in 1995 was 0.06 mrem from the air pathway, 0.20 mrem from the fish pathway, and 0.12 mrem from the drinking water pathway. Strontium-90 analyses of fish tissue samples were not available but have averaged approximately 0.5 mrem in past years. The combined maximum individual dose equivalent was 0.88 mrem (accounting for strontium-90 exposure in the fish pathway) which is 0.88% of the DOE dose limit of 100 mrem and 1.5% of the annual natural cosmic plus terrestrial external dose of about 60 mrem.

5.1.8 Archaeology

Representatives of the New York State Historic Preservation Office toured BNL on June 27, 1990. The only areas of historic and/or archaeological significance identified during this field survey were remnant World War I training trenches located immediately north of BNL's STP, the Old Cyclotron Enclosure, and the Old Reactor Building associated with the former Brookhaven Graphite Reactor. None of the proposed alternatives are located in proximity to any of these facilities.

.2 Site Description, Preferred Alternative

A young growth locust/cherry woodland habitat occupies the proposed construction site of the BAF experimental laboratories and support facilities for the Preferred Alternative. The beam lines's 20^{o} bend would be located in an area currently consisting of paved roadway serving local traffic to AGS and Booster support facilities. This roadway would be relocated to the west side of the new facility. North, east, and south of the proposed facility is currently developed with AGS support facilities and the 200 MeV LINAC. The area immediately northwest of the proposed construction site is occupied by an old growth white pine forest, planted as part of a public works project in the 1930s. This forest is 76.2 meters in width and 91.4 meters deep, measured radially from the proposed facility. The entire area is relatively flat, sloping gradually toward the northwest with slopes of less than 5 percent. The area is essentially located at elevation 21.3 meters above mean sea level. At the edge of the white pine forest, a gradual drop in elevation leads to a perched fresh water wetland dominated by cattails and red maples. Water stands in this wetland year round, partially because of cooling water discharges it receives from operation of the 200 MeV LINAC and because a perched water table is present, a result of soils with a high clay and silt content. Actual depth to ground water in this location is approximately 6.0 meters. Ground water flow is towards the south when AGS supply wells are off and south southwest when the wells are operating. This wetland boundary encompasses BNL Recharge Basin HT which receives discharges as authorized under BNL's New York State Pollutant Discharge Elimination System (SPDES) permit where this recharge basin is designated as Outfall 006.

5.3 Site Description, South Alternative

Disturbed soils, sparsely vegetated natural grasslands, and paved area are the predominant habitat types at the site of the BAF South Alternative. The terrain is rolling with slopes of up to 10 percent. Elevations of the area range from 24.4 to 30.5 meters above mean sea level. The beam line would be located in an area of maintained lawn immediately northeast of the former Radiation Effects Facility (REF). To maintain the elevation of the beam line, it would be constructed up to 9.1 meters below grade. The beam would be reflected toward the east side of the REF, with retaining wall construction required because of the excavation to occur in maintained lawn and paved areas within 9.1 meters of the REF. In future expansion, the final beam line and experimental facilities would be located on paved and sparsely vegetated uplands south of the former REF and Neutral Beam Test Facility and north of Buildings 902 and 905, magnet fabrication facilities. No wetlands are located within 150 meters of the proposed project area. Depth to ground water is 12.2 to 15.2 meters. Ground water flow in this area is also to the south or south southwest depending upon the operational status of the AGS supply wells to the west.

6.0 POTENTIAL ENVIRONMENTAL IMPACTS OF CONSIDERED ALTERNATIVES

Environmental impact is an important criterion used in the alternatives analysis process. The impacts of each alternative are assessed below addressing each of the following phases in project development: construction; operation; and decommissioning.

6.1 Impacts Associated With Project Construction

All proposed alternatives except the No-Action alternative would require the construction of new facilities. The No-Action alternative would continue the current baseline environmental conditions because no changes to the environment are proposed under this alternative.

6.1.1 Commitment of Resources

Because both "build" alternatives require the construction of essentially similar facilities, commitment of natural resources would also be similar. Construction of a BAF would install new beam lines, power supplies, computer equipment, experimental facilities, biological specimen preparation facilities, and new structures to house operations. Raw materials including various metals, rocks, and woods would be used to construct office space, laboratories, magnets, vacuum pipes, beam lines, and beam stops. The BAF would require approximately 15,000 cubic meters of concrete and earthen cover. Fossil fuels and water would be used to produce power to operate construction machinery. All of the resources required for construction and upgrades are readily available in local markets. Some specialized components such as magnets might be manufactured outside the existing area but this should not result in an impact on the availability of raw materials. Energy demands of construction equipment would cause a negligible effect on available supplies.

6.1.2 Environmental Impacts

6.1.2.1 Preferred Alternative

Proposed BAF construction resulting from the Preferred Alternative would be in an area which is now partially paved by an existing roadway connecting the 200 MeV LINAC facility to AGS support facilities and forested area comprised of young growth cherry and locust trees. The composition of vegetative species in the forested area, covering approximately 0.28 hectares, indicates that this parcel of land has been undisturbed for the last 15 to 20 years. No disturbance would occur to the adjacent stand of white pines which were planted in the 1930s. Because development is on a small parcel and at least half cleared with grass on earthen shielding, no significant impacts to wildlife populations are anticipated. During construction the impacted species would be the white-footed mouse and cottontail rabbit, both of which are common at BNL and on Long Island.

No immediate impacts to wetlands or watercourses are anticipated as the nearest wetland is approximately 75 meters to the north/northwest and construction is outside a 0.81 kilometer corridor surrounding the Peconic River, an area typically protected under the New York State Wild, Scenic, and Recreational River Systems Act. Secondary impacts to local wetlands within BNL Recharge

Basin HT (permitted Outfall 006), could result from an increase in paved and semipervious habitat. Runoff discharging to storm water drains that feed HT would increase, possibly increasing discharges of sediments and pollutants common to semipervious and paved surfaces. Use of standard erosion control practices such as hydroseeding should minimize sediment discharges. The increase in water discharged could also have a beneficial impact by increasing the surface area of wetland. The wetland habitat and surrounding areas have only minor variations in elevations so increase in wetland acreage could occur from increased discharges. Wetland hydrology is impacted by three factors: low permeability soils; cooling water discharge; and run off discharge. Depth to ground water at the wetland is approximately 6 meters below grade. None of the proposed alternatives would be constructed in or have an impact on the 100-year floodplain as delineated by the Federal Emergency Management Agency's National Flood Insurance Program.

Noise, traffic, and visual effects would be minor at the BAF. Although 0.28 hectares of habitat would be replaced by several buildings and the BAF target areas would be constructed at grade and covered by 6 to 12 meters of earthen fill for shielding, this visual effect is already present at the adjacent Booster and AGS facilities. The area receives little public traffic and is shielded from the view of the off-site general public by 1,200 meters of mature white pine forest. The rerouting of West Fifth Street would have little impact on traffic as alternative routes to this area are available with similar travel distances. All disturbed areas not paved during construction would be seeded to maintain grasslands on shielding soil or landscaped. Actual clearing of forested habitat would be limited to that necessary for construction and associated parking facilities. All site utilities are present in conduits which cross the site so no additional impacts would be required to make utility connections.

6.1.2.2 South Alternative

Proposed construction resulting from the South Alternative would be in an area which has been subject to continual disturbance recently to construct the former Radiation Effects Facility (REF) and Neutral Beam Test Facility (NBTF). This area has been used as a staging area for construction to the south as well. The resulting habitat that would be disturbed over the 0.28 hectares of needed area is sparsely vegetated grassland and paving in the form of roadway and parking access to the former REF and NBTF. No impacts to the surrounding floral and faunal communities are anticipated since both pre- and post-habitat conditions would be similar. During construction the most likely affected species at this location would also be the white-footed mouse and cottontail rabbit. Similar to the Preferred Alternative, individual organisms would probably attempt to relocate to other adjacent grassland habitats, and repopulate the area once grassland habitats were restored. No wetlands or watercourses are within or adjacent to the project impact area.

Noise, traffic, and visual effects would be moderate for this location. The beam line leading to the BAF experimental facilities would be constructed approximately 6.1 meters below existing grade. This construction would require the installation of a steel retaining wall to protect the structural integrity of the former REF. During construction approximately 6,000 cubic meters of earth would be excavated and stockpiled on adjacent areas pending beamline completion. An additional 16,000 cubic meters of earth would be excavated for completion of the experimental and support facilities. The net impact to the visages of the area would be contour increases of 3.0 to 6.1 meters which reflects the size of the facilities to be constructed and subsequently covered with earthen shielding. These contour changes could aggravate localized erosion of surface soils but vegetative planting and maintenance would control erosion. Active management against soil erosion would be employed since soil erosion changes earthen shielding of the beamline. Runoff would be permitted to recharge in swales created by berm construction.

Traffic patterns would require change. The existing roadway would be eliminated by the presence of the new beamline which bisects the road. To maintain street access from AGS facilities to Booster facilities, a new road would be constructed that would redirect traffic to the east of the new BAF and the former NBTF. The new roadway would be moved approximately 106.7 meters to the west of the current roadway. Construction of this road would require the loss of approximately 0.1 hectares of existing white pine forested habitat.

6.1.3 Impacts on Current Operations

6.1.3.1 Preferred Alternative

For both alternatives that involve construction, connection of the beamline and particle diversion system to the Booster would require approximately three to six months to complete. This action could be scheduled when the accelerator is shut down for routine annual maintenance activities. Under these conditions, no impacts to current operations would result.

6.1.3.2 South Alternative

In addition to breaching the Booster to connect the beamline and particle diversion system, the south alternative also requires the breaching of the LINAC injection tunnel and the TTB transfer line. These breaches are necessary to complete the crossing of these facilities to gain access to the South Alternative location. Breaches would require removal of earthen and concrete shielding, installation of the beamline, and replacement of concrete and earthen shielding. These actions are expected to require 18 months during which time the AGS, Booster, LINAC, and RHIC would have to be shut down. At a minimum, one year of experimental run time would be lost to the users of these facilities. This would represent a severe program impact. In addition, the shielding that must be breached would probably be activated. Up to 40 cubic meters of radioactive waste would be generated by this operation. This material would be packaged at BNL's Waste Management Facility for shipment to DOE's Hanford, Washington facility for final disposal.

6.1.4 Waste Generation and Management

Construction activities other than the breaching of the TTB transfer tunnel and the LINAC injection tunnel to the AGS discussed above would be carried out in a similar fashion. Routine activities for BAF construction would not generate radioactive wastes. Solvents and oils used for cleaning and lubricating would be kept in approved containers meeting the requirements of applicable federal, state, and local rules and regulations at each facility. Contractor operations involving these and other chemicals, such as soaps and paints, would be administratively controlled to ensure that wastes generated from these materials are handled and disposed of properly at offsite locations. Waste generation from routine construction activities is expected to be less than 10 cubic meters of material.

6.2 Effects from Operation

Once constructed, the BAF would be operated the same regardless of location. The following discussion of operational impacts pertains to both build alternatives (Preferred and South). Some discussion of radiation exposures are provided on a facility specific basis because public radiation exposure is dependent upon facility location.

6.2.1 Commitment of Resources

All fresh water available to BNL and surrounding communities comes from an EPA designated sole source aquifer system. Protection of the aquifer requires scrutiny of all operational programs on water consumption and potential contamination. Water consumption at the BAF would be minimized through the use of a closed-cycle heat removal system. It is estimated that the total water consumption of the BAF in cooling systems (in addition to current BNL usage at all existing/proposed facilities), would require 170 liters per minute (LPM) for cooling purposes, of which approximately 57 LPM would be consumed due to evaporation losses. In addition, BAF facilities would require approximately 5,700 liters per day (LPD) for domestic usage. Of the water withdrawn, 8,530 LPM is returned through recharge basins and 2,000 LPM is returned via STP effluents. This water would be drawn from up to ten process and/or supply wells, depending on operational constraints. Since each operational well could help provide water for this increased use, the production increase of each well would be within normal operating fluctuations and would produce imperceptible modifications to existing drawdown impacts in well capture zones.

Water pumpage from the aquifer for the operation of BAF would represent a total increase in BNL pumpage of 1% and an actual increase in annual water usage of 0.7%, which is about 17,055 LPM withdrawn. Based upon the 1995 Water Table Balance for BNL, BAF's actual requirements of 82,080 LPD represent only 0.5% of the Margin of Safe Yield volume of 17,055,000 LPD available to BNL.[11] This increase would be well within past operating conditions which have decreased 10% since 1985 as a result of the implementation of various water conservation activities. Pumpage required by this project is well within permitted pumpage volumes for BNL supply wells.

The BAF is projected to require 0.5 MW of electrical power, which is 20% of the 2.5 MW required for operation of the Booster. Current peak electrical demand by BNL is 45 MW. Peak electric use is expected to increase to 80 MW when the RHIC becomes operational. The extra load due to the BAF would be essentially constant, with low variation at times of shutdown and start up. Power is now supplied to BNL by the New York Power Authority (NYPA) from electricity generated at the Fitzpatrick Nuclear Power Plant located near Oswego, New York. Approximately 84% of BNL's energy demands are met by NYPA with the additional 16% being met by the Long Island Lighting Company (LILCO). The NYPA has indicated that the Fitzpatrick plant has 75,000 kilowatts available for industrial customers and would seriously consider a request for additional allocation to BNL. The Long Island Lighting Company has also indicated it has adequate capacity and could supply additional BNL energy demands. No additional construction would be required offsite to meet the additional energy demands created by the BAF. A 108 square meter building is proposed which would facilitate power distribution to the various operational and experimental programs associated with the facility.

The BAF and support buildings to be constructed would increase the building occupied space at BNL by 0.2%. This small increase would have an imperceptible impact on use of fossil fuels and electricity to meet heating and air conditioning needs. Because the BAF tunnel would be covered with earthen shielding, the primary function required for climate control would be dehumidification. The BAF target hall would be covered with shielding and would be air conditioned.

For BAF operations, environmental concerns are associated water and air effluents. A recently upgraded tertiary STP is operated by BNL with authorization to treat 6.8 million LPD of sanitary discharge. The plant is currently operating at approximately 45% of capacity. Domestic sanitary waste is the only effluent expected to be discharged to sanitary lines on a routine basis from BAF. The volume of this discharge is not expected to exceed 5,700 LPD which is less than 0.1% of the current authorized treatment plant limit. Connection to sanitary would be made for all BAF facilities. It is not anticipated that radioactive materials would be discharged from any of the facilities connected to the sanitary system.

The BAF would be supported by maintenance facilities currently existing at BNL. These facilities have NYSDEC authorized air emission points associated with them for activities such as vapor degreasing, paint spraying, welding, sandblasting, baking, plating, and polishing. The BAF would also have laboratory facilities where fume hoods would discharge trace amounts of organic solvents, acids, bases, and vapors from other commonly used laboratory chemicals. Pending the availability of detailed design for air emission points and the type and use of laboratory chemicals, air emissions from laboratories are generally regarded as insignificant and are exempt by the NYSDEC from obtaining authorization to construct and operate. Additional demands of BAF are not anticipated to require permit discharge limit modifications at existing facilities as operations should be well within the normal fluctuation of activities at BNL.

6.2.2 Waste Generation and Management

During BAF operations some beamline components may become activated. If any of these components were to fail, they would be removed from service and placed in indoor, shielded holding areas subject to controlled access. The items would be repaired, salvaged, or packaged and moved to BNL's hazardous waste storage facilities for secure storage and eventual shipment offsite as low level radioactive waste. Other hazardous or radioactive wastes generated during operations, such as from maintenance, would be handled in a similar manner. The Laboratory has recently had commissioned a newly constructed waste management facility which will be in operation prior to selecting any of the proposed alternatives. This new facility has been designed to minimize the potential for environmental releases.

Besides the packaging of wastes for disposal, BNL has instituted an aggressive waste minimization program which includes inventory control, material and process substitution, waste segregation, toxicity reduction, and recycling. Wastes expected to be generated during operation of BAF would be disposed of as described below:

- Solid waste which is non-hazardous and non-radioactive would be disposed of through the services of an offsite vendor. For BNL, the BAF would increase the generation of solid waste approximately 7,200 kilograms per year or approximately 0.5% of BNL's current solid waste stream of 1.35 million kilograms.

- Hazardous non-radioactive waste would be disposed of via the services of a group of firms presently under contract to BNL. Disposal services are typically comprised of incineration, landfilling and/or resource recovery, depending on the particular waste stream involved. These operations are performed at various permitted facilities around the United States. The BAF is expected to generate 450 kilograms per year of hazardous waste or less than 1% of the 70,000 kilograms generated by BNL in 1995.

- Low level radioactive waste would be compacted and shipped to, and disposed of, through burial at the Hanford site in the State of Washington. Initial handling and packaging of the waste would be accomplished on location by AGS Department personnel and then transferred to BNL's Hazardous Waste Management Facility (HWMF). Radioactive waste generated by BAF would total 1.5 cubic meters of material compared to current BNL operations which generate 450 cubic meters of material per year.

Depending on experimental operations, some and/or all components of the waste stream at the BAF may be increased to 5% of current BNL waste generation. On-site storage of hazardous and mixed waste is limited to 320 two hundred eight liter drums given adequate secondary containment. No limitation is imposed on storage of radioactive wastes. Hazardous waste storage is further limited as follows: 80 drums of flammable waste; 80 drums of acid waste; 80 drums of bases and solvents;

and 80 drums of oil wastes. Shipment of materials off site is conducted in a manner such that storage space is not limited. The Waste Management Facility also includes facilities for decontamination, segregation, and packaging.

6.2.3 Environmental/Radiological Effects

Once operational, all direct environmental impacts associated with the proposed build alternatives, beyond those alluded to in Sections 6.2.1 and 6.2.2, would be limited to radiation exposures. The radiological effects calculated for the BAF are presented in the following sections. Information is provided only for standard heavy ion operations because safeguards designed in the operation of the Booster would contain a fault or abnormal event involving protons within the Booster proper. Such events would have no relevance to the BAF. The data was obtained from the Final Safety Analysis Report prepared for the Booster and special calculations generated by BNL personnel. With the exception of direct radiation, location is not a significant factor for the other categories discussed for the given build alternatives.

6.2.3.1 Direct Radiation

Although the laboratory site is considered to be a limited access facility, service personnel from offsite and BNL non-radiation workers may work or visit near the BAF. Laboratory policy for such personnel is to restrict the annual dose to less than 25 mrem/year. This goal would be accomplished through shielding design that would reduce the BAF's average contribution to the dose rate outside the BAF areas of transient occupancy to less than 0.5 mrem/hour.

6.2.3.1.1 Preferred Alternative

During BAF operating periods, building 919 would be the closest uncontrolled location to Preferred Alternative BAF location with full-time worker occupancy, a distance of 150 meters. Portions of Building 919 are controlled radiation areas during present operating periods for the accelerator complex. Non-radiation worker personnel are present in the building. Personnel in this building would be exposed to earth shine and skyshine radiation due to routine losses. Administration goals of BNL require dose rates to on-site non-radiation workers to be no more than 25 mrem/year and off-site individuals no more than 5 mrem/year. Given the size and thickness of shielding proposed for BAF, the calculated outer shield surface exposure would yield 0.002 mrem/hour. This translates into dose rates of 0.000027 mrem/year at the site boundary and 0.00013 mrem/year at Building 919, both of which are less than one ten thousandth of their respective administrative limits.[12]

6.2.3.1.2 South Alternative

The former REF Building would be the closest uncontrolled location to the South Alternative BAF location with potential for full-time worker occupancy, a distance of 100 meters. As with the Preferred Alternative, the calculated outer shield surface exposure anticipated would be 0.002 mrem/hour. This would produce dose rates of 0.000027 mrem/year at the site boundary, unchanged from the Preferred Alternative, and 0.00038 mrem/year at the REF Building. The exposure at the former REF Building would be three times that experienced by non-radiation workers at Building 919 under the Preferred Alternative but still less than one ten thousandth of the BNL administrative limit of 25 mrem/year.

6.2.3.2 Soil Activation and Ground Water Effects

Secondary particles created by beam interactions would escape into the earth beneath the BAF experimental area and beam stop. Soil would not be used on top of or on the sides of the experimental hall or beam stop in any of the build alternatives. Some of the particles would interact with the silicon and oxygen atoms present in the soil to form possibly such radionuclides as tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22. Once present in the soil these radionuclides may be leached downward to ground water by rain and then transported by natural ground water movement to potable water supply wells both onsite and offsite. These processes are extremely slow and only the longer lived radionuclides tritium and sodium-22 would have a potential to move away from the project footprint prior to decay to background levels.

Radionuclides could be created in soil particles within the first meter of soil beneath the target and beam stop shields. Shield design for all build alternatives would be of appropriate thickness to minimize the potential for secondary particle interactions beneath the facility. Should radionuclide creation occur despite the shielding in place, the shielding would also act as a barrier to any water infiltration at the surface that could drive these radionuclides through the existing six meters of soil to permit their movement into the Upper Glacial Aquifer. Conservative estimates indicate that initial radionuclide contamination of soil water at the point of creation would be approximately 2,000 pCi/L. By the time this radionuclide containing soil water could be leached from beneath the facilities, move into ground water, and migrate to any onsite or offsite potable water supply well, these radionuclides would be expected to have fully decayed and not be detectable above background concentrations.

6.2.3.3 Emission of Airborne Radioactivity

Each alternative for the BAF would minimize beam interactions in air. The beam would be transported in a vacuum pipe to the target area which would require approximately one linear meter of open space between the vacuum line and the target. Air activation products that could be produced in small quantities through interaction of the beam with air are tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-14, oxygen-15, and argon-41. The target room in which these radionuclides would be created would consist of air conditioned, recirculated air. Under normal operating conditions there would be no exhaust of the target room air. All radionuclides that would be generated are short lived and would be expected to decay to stable, non-radioactive atoms within the target hall.

Under abnormal operating conditions, which would be expected to occur at a frequency of less than once per year, it may be necessary to vent the target hall causing a release of the generated air activitation products. Calculations of the potential annual dose that may be received by both onsite and offsite personnel was calculated for each alternative using the following assumptions: wind speed of 3 meters/second used to account for decay in transit to the site boundary; distance to the site boundary is 1,400 meters; and ratio of air concentration to activity release rates varies by up to two orders of magnitude for a constant wind speed for the distances under review. At 1,400 meters, the ratio of ground-level air concentration to activity release rate would range from 1 x 10^{-12} to 1 x 10^{-10} seconds/cubic centimeters. At 100 meters, range would be 3 x 10^{-11} to 5 x 10^{-10} seconds per cubic centimeter. If the wind is in any one direction for up to 10% of the time as indicated in 1995 wind rows data for BNL, then a person would be exposed 150 hours out of the 1,500 hour annual operations assuming constant ventilation of the target hall. Under these conditions, the maximally impacted onsite individual would receive a dose of 0.002 mrem per year and an individual at the site boundary would receive a dose of 0.00009 mrem per year. This information is provided in further detail in Table 6-1.

Activation products attributed to experimentation at the BAF may also be discharged through the incineration of disposed experimental materials. Current BNL operations include the incineration of biological materials produced by research involving the MRR. Incineration is conducted at an onsite unit currently permitted by the New York State Department of Environmental Conservation. Releases of radioactivity have varied greatly depending upon the intensity of the beam used in experimentation and the number of biological specimens. Common radionuclides encountered in space radiation research are tritium, carbon-11, nitrogen-13, oxygen-14, oxygen-15, sodium-22, phosphorus-32, sulfur-35, and argon-41. During 1995, BNL incinerated radionuclides of tritium, cobalt-57, strontium-85, and iodine-125. Taking these incineration practices into consideration, the estimated dosimetric impact of operating the Booster and BAF may be up to 0.02 mrem maximum at the site boundary to an individual and 0.009 person-rem collective dose.[4] The total dosimetric impact due to air emissions from operating Booster and all other facilities including the projected operation of RHIC would be a maximum 0.2 mrem to an individual at the site boundary and a collective dose of 3.109 person-rem under 1995 operating conditions.

6.2.3.4 Summation of Health Effects

Using the information provided in Sections 6.2.3 through 6.2.3.3, health effects resulting from proposed BAF operations were estimated. Estimates were prepared using the recommendations in Report 60 prepared by the International Commission on Radiological Protection (ICRP).[13] This report uses the most recent risk estimates in the Biological Effects from Ionizing Radiations Report issued by the National Academy of Sciences (NAS).[14] Assumptions used in the estimate were: a member of the general public resides on the site boundary closest to each facility, 24 hours a day, 365 days a year; and occupancy is continuous for the projected 10 year life of the proposed operations. If continuous inadvertent airborne release occurred, then the calculated total radiation dose to this individual over a 10 year period would be 0.0009 mrem from BAF. This dose would be 9 orders of magnitude below respective background levels. Using the ICRP and NAS methods of risk prediction, the additional risk of a person residing at the site boundary to contract a fatal cancer would be less than one chance in a billion. Given this information, no radiation health effects are expected to occur.

Table 6-1 Air Activation Production and Generated Dose to Maximally Effected Onsite and Offsite Individuals, Assuming Continuous Ventilation of BAF Target Hall During Operations

Radionuclide Produced In Air activation	Half Life in seconds	Production Rate in One Meter of Air for BAF Beam Intensity in Ci/sec	Maximum Inadvertent Onsite Air Activation Concentration, microCi/cc	Maximum Inadvertent Offsite Air Activation Concentration, microCi/cc	Maximum Inadvertent Onsite Annual Dose, mrem	Maximum Inadvertent Offsite Annual Dose, mrem
H-3	6.46E+06	2.43E-14	1.22E-17	2.43E-18	2.28E-10	4.56E-11
Be-7	4.58E+06	5.68E-13	2.84E-16	5.68E-17	1.18E-08	2.36E-09
C-11	1.20E+03	2.43E-09	1.19E-12	1.82E-13	8.95E-07	1.37E-07
N-13	6.00E+02	4.86E-09	2.34E-12	2.73E-13	5.27E-04	6.14E-05
O-14	7.20E+01	9.73E-10	3.54E-13	7.91E-16	7.97E-05	1.78E-07
O-15	1.26E+02	2.03E-08	8.45E-12	1.30E-13	1.90E-03	2.92E-05
Ar-41	6.59E+03	1.54E-10	7.68E-14	1.46E-14	9.60E-06	1.83E-06
Total Annual Dose, mrem					**2.52E-03**	**9.27E-05**

6.3 Decontamination and Decommissioning

The Booster provides accelerated protons and heavy ions for a multiple user community where the only dedicated space radiation facilities would be the BAF. Induced radioactivity in the BAF would be limited to some experimental detectors, beam stops, transfer magnets, and some vacuum equipment. These components would be categorized as low level waste and would be shipped for disposal offsite at existing federal facilities. Estimates of the amount of low level radioactive waste that would require disposal for the Preferred Alternative, assuming no components would be reusable, would amount to approximately 100 cubic meters. Construction debris from dismantling the BAF at the Preferred Alternative location would include approximately 2,800 cubic meters of concrete, 55,000 kilograms of steel, 9,000 kilograms of copper, and 11,000 kilograms of miscellaneous materials. To access the BAF and beam transport lines would require the excavation of 15,000 cubic meters of earthen shielding which would be stockpiled and regraded following tunnel and component removal. After removal of soils containing tritium and sodium-22 the remaining soil would be regraded. Future site utilization would have no restrictions other than surrounding land uses.

For the South Alternative, the amount of low level radioactive waste generated would be approximately 140 cubic meters because of the need to excavate and remove materials adjacent to the TTB tunnel and the LINAC to AGS tunnel. Construction debris from dismantling the BAF in the South Alternative location would include approximately 3,200 cubic meters of concrete, 63,000 kilograms of steel, 10,000 kilograms of copper, and 13,000 kilograms of miscellaneous materials. Approximately 22,000 cubic meters of earthen shielding would be removed and regraded to gain tunnel access. As with the Preferred Alternative, soils contaminated with tritium and/or sodium-22 would be removed and disposed of as low level radioactive waste.

Doses to site workers during decommissioning and dismantlement for either alternative would be expected to be minimal since no components would become activated above a low level radiation hazard and decay of radioactive isotopes would occur from the time beam was last in the facility to the time when actual dismantlement would occur. Under current operations, actual dismantlement of this facility could occur 5 to 10 years after shutdown with minimal radiation exposures to workers. Detailed discussion of decommissioning would be reserved for a separate NEPA document to be prepared near decommissioning when detailed data would be available.

6.4 Environmental Justice

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority and Low-Income Populations,” requires federal agencies to analyze disproportionately high and adverse environmental effects of proposed actions on minority and low-income populations. All alternatives evaluated in this environmental assessment involve potential environmental impacts which would either be contained within the BNL property boundaries or impact communities immediately adjacent to these boundaries. The areas within the Laboratory and immediately surrounding the Laboratory contain neither predominantly low-income nor minority populations.

7.0 SUMMARY OF IMPACTS INCLUDING CUMULATIVE OPERATIONS

7.1 Summary of Impacts Specific to BAF Construction and Operation

The No-Action Alternative would provide for no construction of a new space radiation research facility. The space program would shift research activities to existing facilities. However, utilization of facilities which do not provide the proper energies would seriously effect capabilities of the space radiation research program.

Common to each build alternative, the operation of the BAF to service long term space radiation research would require 170 LPM of water for cooling and 0.5 MW of electricity. These utility usages represent 1% and 0.1%, respectively, of projected BNL demands which is well within usage fluctuations. A total 8,700 kilograms of non-hazardous solid waste, 450 kilograms of hazardous waste, and 1.5 cubic meters of radioactive waste would be generated from BAF operations annually. These quantities represent 1% or less of BNL's current relevant waste streams. Contributions of tritium to drinking water would be minimal to zero. Air activation products produced at BAF would be tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-14, oxygen-15, and argon-41 in small quantities. The dose to an individual at the site boundary from these inadvertent releases would be 0.00003 mrem/year, well below the allowable standard of 10 mrem/year. Construction and decommissioning impacts for each build alternative are displayed in Table 7-1.

The Preferred Alternative would result in an onsite dose rate of 0.0025 mrem/year and a site boundary dose rate 0.000093 mrem/year only if airborne emissions inadvertently were to occur. Otherwise, the facility is planned to operate such that zero exposure outside the target hall and laboratory areas would occur.

The South Alternative, under the inadvertent release scenario, would result in an onsite dose rate of 0.00038 mrem/year and a site boundary dose rate of 0.000027 mrem/year. These exposure rates are far below BNL's administrative limits of 25 mrem/year to site nonradiation workers and 5 mrem/year to offsite personnel.

7.2 Cumulative Impacts Associated with BAF and Other Laboratory Activities

Cumulative BNL operation releases including BAF and the proposed RHIC facility would result in a dose of 0.2 mrem/year to an occupant at the site boundary and a collective population dose equivalent of 3.109 person-rem under 1995 conditions or five orders of magnitude below background. All other impacts associated with BAF are within the fluctuation of normal Laboratory operations.

Table 7-1 Construction and Decommissioning Impacts of the Preferred and South Alternatives

Category of Impact	Preferred Alternative	South Alternative
Construction		
Habitat Loss	0.28 hectares	0.1 hectares
Contour Changes	None	-7.0 meters
Earth Movement	15,000 cubic meters	22,000 cubic meters
Hazardous Waste	10 cubic meters	10 cubic meters
Radioactive Waste	None	40 cubic meters
Traffic Rerouting	Minor	Moderate
Booster Shutdown	6 months	18 months
TTB Tunnel Shutdown	None	18 months
LINAC Tunnel Shutdown	None	18 months
Wetlands/Surface Water	None	None
100 Year Floodplain	None	None
Ground Water	None	None
Historic Resources	None	None
Endangered Species	None	None
Decommissioning		
Radioactive Waste	100 cubic meters	140 cubic meters
Concrete Debris	2,800 cubic meters	3,200 cubic meters
Steel Debris	55,000 kilograms	63,000 kilograms
Copper Debris	9,000 kilograms	10,000 kilograms
Earth Movement	15,000 cubic meters	22,000 cubic meters
Miscellaneous Debris	11,000 kilograms	13,000 kilograms

8.0 REFERENCES

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9.0 ACRONYMS

AGS	Alternating Gradient Synchrotron
BAF	Booster Applications Facility
BNL	Brookhaven National Laboratory
CFR	Code of Federal Regulations
DAS	Department of Applied Science
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
GeV	Giga (Billion) Electron Volts
GeV/c	Billion Electron Volts per speed of light
HWMF	Hazardous Waste Management Facility
ICRP	International Commission on Radiological Protection
LILCO	Long Island Lighting Company
LINAC	Linear Accelerator
LPD	Liters Per Day
LPM	Liters Per Minute
MRC	Medical Research Center
mrem	millirem
MRR	Medical Research Reactor
MW	Megawatts
NAS	National Academy of Sciences

NASA	National Aeronautics and Space Administration
NBTF	Neutral Beam Test Facility
nCi/L	Nanocuries per liter
NYPA	New York Power Authority
NYSDEC	New York State Department of Environmental Conservation
pCi/L	Picocuries per liter
pCi/m^3	Picocuries per cubic meter
REF	Radiation Effects Facility
RHIC	Relativistic Heavy Ion Collider
SPDES	State Pollutant Discharge Elimination System
STP	Sewage Treatment Plant
TeV	Tera (Trillion) Electron Volts
TTB	Tandem to Booster
VUV	Vacuum Ultraviolet
WMF	Waste Management Facility

10.0 DEFINITIONS

Activated materials - Material made radioactive by the bombardment with neutrons, protons, or other nuclear particles.

Collective dose equivalent - The summation of the absorbed radiation dose received by all individuals in a population group.

Corrosives - Aqueous solutions having a pH below 2.0 or above 12.5.

Cosmogenic - Generated by a stream of ionizing radiation of extraterrestrial origin.

Curies - A unit of activity equal to 3.7×10^{10} atoms per second disintegrations.

Direct exposure - Radiation encountered through proximity to an external source.

Evapotranspiration - Form of respiration employed by plants where water is removed from the soil and oxygen is released through the leaves.

Environmentally acceptable manner - Performing an action following a procedure that would not cause or produce a long term adverse impact on the surrounding environment.

Fauna - Animal life.

Flammables - Materials with a flashpoint of under 100^{o} Fahrenheit.

Flora - Plant life.

Hazardous waste - A solid, liquid, semisolid, or gaseous material which may pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.

Liquefaction - Process by which under extreme turbulence a solid is transformed into a liquid like mixture.

Low level radioactive waste - Solid, liquid, and gaseous materials from nuclear operations in the range of 1 microcurie per gallon or cubic foot.

Mixed waste - Material to be disposed of which contains both a hazardous and radioactive component.

mrem - A special unit of absorbed dose equivalent equal to the absorbed dose in rads multiplied by a quality factor.

Nucleon - A proton or neutron especially as part of a nucleus.

Oxidizers - Materials that can cause ignition, combustion, or detonation of organic materials, powdered metals, and other reducing agents.

Percolation rate - Speed at which one material can pass or ooze through another material.

Person-rem - Unit of population exposure obtained by summing individual absorbed dose values for all people in the population.

Primordial - Originating from the being of time.

Radioisotope - A naturally occurring or artificially produced radioactive isotope (same element, different atomic weight) of an element.

Radionuclides - Any radioactive form of an element.

Sky shine - Radiation reflected back to earth by the atmosphere above a radiation-producing facility.

Sole source aquifer - A layer of ground water determined to be the only available source of drinking water to a defined region or population.

Waste minimization - Effort by hazardous waste generator to reduce the volume and toxicity of waste whenever possible as required under EPA regulation 40 CFR 262.

Zone of capture - Surface recharge area and all subsurface flow regions from which a pumping well receives water.

11.0 LIST OF AGENCIES CONSULTED

New York State Department of
Environmental Conservation
Stony Brook, New York
(516/751-7900)

New York Natural Heritage Program
Delmar, New York
(518/783-3901)

New York State Historic
Preservation Office
Albany, New York
(518/474-0479)

U.S. Department of Energy
Chicago, Illinois
(630/252/2101)

U.S. Department of Energy
Upton, New York
(516-344-3424)

U.S. Environmental Protection Agency
New York, New York
(212/264-5170)

U.S. Fish and Wildlife Service
Cortland, New York
(607/753-9334)

U.S. Geological Survey
Syosset, New York
(516/938-8830)